

**FORECASTING PRE-WORLD WAR I INFLATION: THE FISHER EFFECT
AND THE GOLD STANDARD***

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I. INTRODUCTION

The issue examined in this paper—closely linked to Irving Fisher, and no closer to resolution now than when it first arose a century ago—is the puzzling behavior of interest and inflation rates during the classical gold standard period before World War I from 1870 (when the post-Civil War United States declared its intention to adopt gold) to the breakdown of the international gold standard in 1914. During the first half of this period the United States underwent deflation. From 1870 to 1896 the national product deflator of Friedman and Schwartz [1982] declined at an average rate of 1.1 percent per year, although shorter-term price changes were erratic. This trend was then reversed—over the period 1896-1914, the United States price level increased at 2.5 percent per year. A comparable shift in inflation is exhibited by the Warren-Pearson wholesale price index. A similar though less extreme shift for the United Kingdom is seen in the GNP deflator (Friedman and Schwartz [1982]), in the Sauerbeck-Statist wholesale price index, and in the Rousseaux wholesale price index (Mitchell and Deane [1965]). Plots of the American and British price levels exhibit a pronounced “V” shape, with a turning point in 1896.

Irving Fisher’s theory of interest (Fisher [1930]) holds that steady-state nominal interest rates adjust one-for-one to changes in steady-state inflation; it thus suggests that nominal rates should have been some 300 basis points higher along the rising portion of the “V” than during 1879-1896. Although cyclical movements in real rates (for example, Friedman’s [1969] liquidity effect) might mask the correlation of interest rates and inflation in the short run, in the long run there should be a one-to-one relationship between changes in inflation and changes in nominal rates.¹ But as figures 2 and 3 show neither short- nor long-term interest rates display the Fisherian pattern.² Instead, interest rates exhibit the much-debated “Gibson paradox”: they appear correlated not with inflation but with the price level itself (for example, see Shiller and Siegel [1977] and Barsky and Summers [1988]). Short-term³ and especially long-term⁴ interest rates mirror price indices, falling gradually during the 1870-1896 period of deflation, and then displaying an upturn.

Circumstances peculiar to the United States almost certainly played a part in the failure of interest rates to adjust. Some component of high rates before 1897 may be a premium to offset the possibility that the United States might abandon the gold standard, and some may reflect the default premium attached to US railroad bankruptcies.⁵ However, the paradox remains if we examine nominal rates that are essentially on a gold basis. The failure of interest rates to rise in response to the change in the drift of prices is striking in Britain as well, though there was almost no chance that the United Kingdom would abandon the gold standard. Table 1 shows mean inflation and interest rates for the United States and

United Kingdom for the two subperiods.

A shift in average inflation could have failed to induce any shift in nominal interest rates because of some offsetting shift in the real marginal product of capital, but there are few signs of a marked shift in the marginal product of capital between the pre- and post-1896 periods. The rate of consumption growth in the United Kingdom did fall by about one percent per year after 1896,⁶ but the rate of consumption growth in the United States and the rest of the industrializing world did not (see Lewis [1978]; Maddison [1982]; and Matthews, Feinstein, and Odling-Smee [1982]). Since the world capital market was highly integrated before World War I—United Kingdom capital exports averaged about five percent of GNP over 1870-1914—world rates of return are presumably the relevant measures of the marginal product of capital. Moreover, Barsky and Summers [1988] and Hirschfeld [1988] find no shift in dividend/price ratios after 1896, as figure 4 shows. Such a shift would be expected to result from a fall in ex ante real interest rates. We therefore do not pursue explanations that rely on shifting required real rates of return.

These facts about pre-World War I interest and inflation rates frame our paper, which focuses on three questions: (a) Did shifts in average rates of inflation before World War I significantly distort the allocation of resources and was Fisher's theory that real interest rates should be independent of steady-state changes in average inflation rates inappropriate for the pre-1914 period? (b) Did investors fail to process available information in a careful and utility-maximizing way, leaving them with systematically biased expectations? (c) Can the pre-World War I non-adjustment of nominal interest rates be reconciled with the twin assumptions of steady-state monetary superneutrality and rational expectations?

In this paper we take a position halfway between (b) and (c). Investors did fail to shift their forecasts in response information about the long-run supply of gold, information that the quantity theory should have taught them was highly relevant to the determination of the long-run rate of drift of the price level. On the other hand, the debates and discussions of economists and journalists of the time reveal great uncertainty about the structure of the economy and the relevance of the quantity theory. Given the state of academic and journalistic knowledge, we find ourselves unable to say that investors' expectations were in any meaningful sense less than "rational": investors' expectations reflected careful and utility-maximizing assessments of available information in a context of uncertainty as to the relevant economic theory. Informed investors were certainly very conscious of past changes in the price level and of prospective future changes.⁷ But their forecasts were systematically off because they chose to evaluate available information using the wrong—that is, an ex post erroneous—theory of price-level determination.

The plan of the paper is as follows. Section II reviews the debate over the pre-World War I non-adjustment of nominal interest rates. Section III reviews the historical circumstances surrounding nineteenth century gold discoveries—those in California and Australia in the middle of the century, and especially those in South Africa at the end. We also discuss the role of new technology—the cyanide extraction process—and heavy capital investment in transforming the discoveries of the late nineteenth century into actual gold. Section IV examines the forecastability of inflation before 1914 from a statistical point of view. Although inflation is to a first approximation a martingale difference with respect to its own past (loosely speaking, the log of the price level is almost a random walk), there is a component of future price changes that is forecast by changes in the world stock of gold. The smooth gold production series appears to pick up an important and forecastable low-frequency component of inflation which is masked in low-order univariate analysis. We present instrumental variables estimates of the relation between interest rates and the component of inflation forecast by lagged gold production. These estimates provide no support for the Fisherian theory of interest. Instead, they support the views of Fisher [1930] in his nihilistic guise and of Summers [1983].

Section V argues that the linear statistical forecasting approach of section IV may take a naive view of how investors acquire information in a complex world and lead to an excessively harsh verdict both on the question of the response of interest rates to expected inflation and on the question of the rationality of investors. Quoting from contemporaneous reports of the Economist, we note the reluctance of its editors to present forecasts of positive future inflation even though they provide extensive coverage of gold mining operations and are ideologically strongly committed to the quantity theory. We suspect that the editors' reluctance to forecast inflation may have been a reasonable response to doubts about the sustainability of higher gold production levels and to uncertainty about the future evolution of gold velocity and real growth. Commentators interpreted the evidence through an ex ante reasonable—even if ex post incorrect—theory of price level determination.

A final section, section VI, sums up the argument. And an appendix considers the possible implications for our argument of the free silver movement in the United States.

II. THE ISSUES

There have been many attempts to explain why pre-World War I interest rates do not display a Fisherian pattern. Friedman and Schwartz [1982] follow Fisher's own [1930] attempt to reconcile the

Fisher effect and the Gibson paradox and speculate that expectations adjusted to persistent shifts in inflation only after a long lag. Yet they also express considerable doubts about this line of thought, particularly the twenty-year lag in the formation of expectations needed if the Gibson paradox is seen as a delayed Fisher effect.

Fisher himself [1906], perceiving a marked change in the secular rate of inflation which he saw as directly linked to the greatly-increased output of the world's gold mines, provided a scathing attack on the relevance of his own theory of the relation between interest rates and inflation:

during 1898-1905 the increase of prices in the United States is known to have been due largely to the increase in gold production.... There seems, therefore, no reason which would justify the low commodity [real] interest rate of 1.8 percent which we found to have been virtually paid during that period. This low rate must, in all probability, have been due to inadvertence. The inrushing streams of gold caught merchants napping. They should have stemmed the tide by putting up [nominal] interest, not only to 4.6 percent, as they did, but two or three percent higher...

Fisher's ascription of such a degree of "inadvertence" to the "merchants" of 1898-1905 is surprising given his strong rejection only twenty pages earlier in The Rate of Interest of the possibility that investors might suffer from money illusion and fail to notice that their nominal return i was different from their real return r :

Foresight is clearer and more prevalent to-day than ever before. Multiples of trade journals and investors' reviews have their chief reason for existence in supplying data on which to base prediction. Every chance for gain is eagerly watched for. An active and keen speculation is constantly going on which, so far as it does not consist of fictitious and gambling transactions, performs a well-known and provident function for society. Is it reasonable to believe that foresight, which is the general rule, has an exception as applied to falling or rising prices?

Summers [1983] focused explicitly on the long run in which Fisher's effect should hold, found no correlation between short-term or long-term rates and inflation rates in United States data before 1940, and concluded that "[t]he data... raise the possibility that... money illusion infects financial markets. All are explicable by the hypothesis that before the war agents ignored inflation in making financial calculations" (Summers [1983], p. 232). Summers, Fisher [1930], Friedman and Schwartz [1963] and [1982], and other commentators like Cagan [1984] are thus aligned in support of a "traditional" view that the pre-World War I period saw two distinct régimes: an era of falling prices before and an era of rising prices after 1896, with the change in régimes triggered by the increase in gold production and thus

foreseeable by investors at the time.

Barsky [1987] provides the most recent example of a second, alternative account of the lack of correlation between interest and inflation rates before 1914. He notes, as did Sargent [1973], Shiller and Siegel [1977], Benjamin and Kochin [1984], and others, that inflation was approximately serially uncorrelated during this period. Thus the simplest ARIMA forecast of inflation from the pre-World War I data is constant and equal to the sample mean.⁸ If investors were unable to forecast shifts in expected inflation then, as McCallum [1984] pointed out, the lack of correlation between interest and inflation rates did not carry information about the Fisher effect, but only reflected the failure of past inflation to signal future inflation.⁹

There are thus two contrasting views. The view sympathetic to Fisher's theory emphasizes that hindsight is always 20-20, that the switch in the average rate of inflation which from an ex post viewpoint took place in 1896 was not necessarily seen as such at the time, and that there is little formal evidence that inflation before World War I was forecastable even with the tools of modern time series analysis. The alternative, not reconcilable with Fisher's theorizing—though it does fit his own rather nihilistic interpretation of the empirical evidence—seems more compatible with historians' sense that investors perceived, or should have perceived, long swings in the trend of prices. The present paper tries to bring out the elements of truth in both views, and to assess the extent to which Fisher was correct in rejecting his own theory on the basis of the pre-World War I evidence.

In this paper we try to infer both what investors should have thought about future inflation and what investors did think as revealed by the reporting of the financial press. Most important, we assess the value of information on gold mining in forecasting future changes in average inflation rates. We find that gold production helps to forecast inflation (albeit with a small R^2). This may appear surprising in view of the fact that gold mining is persistent while inflation appears close to white noise. But gold production is a reliable signal of a subtle persistent component in inflation that is sufficiently buried in short-term noise as to escape detection by low-order univariate ARIMA models. The inclusion of gold production in a model is necessary to lend inflation a degree of forecastability. The coincidence of the expansion of gold production and the shift to an upward drift in the price level lends us confidence—through the force of the quantity theory—that the “V” in the price level is not a spurious pattern.

Because we find some forecastability in inflation, and yet no Fisher effect in the pre-World War I data, we conclude that by the standard rules of the game—according to which economists presume that investors know both the appropriate economic theory to apply and the parameters of the economy—

Fisher's rejection of his own theory is justified, and Fisher and Summers have good reason for suspecting a failure of market "rationality." We confirm Fisher's belief that by the first few years of this century "expected inflation" (thought of as the linear projection of inflation on simple and publicly available information sets) should have been several hundred basis points higher than in 1895.¹⁰ Using gold production as an instrumental variable for expected inflation, we estimate the response of nominal rates to changes in "expected inflation" to be essentially zero.

We go on to argue, however, that at a more substantive level Fisher and his sympathizers are likely to have overstated their case. The equation relating inflation to lagged gold production is not a structural but a reduced form relationship. And the quantity theory, which would have led one to expect such a reduced form, was not as strongly held in 1900 as we hold it today. A more realistic and sophisticated view of information processing should take into account the fact that econometricians can choose models with the benefit of hindsight, while agents must act without reflecting from a future standpoint on the structure in which they are embedded. Such a view would lead to a less harsh judgment as to the validity of the underlying Fisherian theory.

III. GOLD DISCOVERIES AND MINING TECHNOLOGIES

Key to any discussion of the price level under the gold standard is an analysis of a central determinant: the quantity of gold.¹¹ In this section we provide a brief survey of the historical circumstances surrounding the Australian and South African gold discoveries, and the development and commercial implementation of the cyanide process for gold extraction. The history of gold production in the nineteenth century is dominated by the two "rushes" of the 1850's and the 1890's. From the perspective of a century or more, these rushes are perhaps best seen as endogenous responses to industrialization: the gold was there, and would be discovered and mined at some point if the price of gold were high enough. But from the standpoint of a decade or a generation, the two expansions in gold production take on the character of exogenous shocks to the world's monetary system. Figure 5 shows contemporaneously available estimates, reported in the Financial Review Annual supplement to the New York Commercial and Financial Chronicle, of world gold production up to the outbreak of World War I; figure 6 concentrates on the period since 1800 and shows the same data in the form of the proportional rate of increase of the world's cumulative mined gold stock. Annual gold production increased by a factor of five during the gold rushes of the 1850's, and then leveled off in the 1870's and 1880's. Gold

production then doubled from its level during the 1870's and 1880's in the 1890's, and had doubled once again by 1910. The proportional rate of increase in the world's gold stock thus exhibits two peaks, in the 1850's and 1910's, and an intermediate trough. The two rushes are not of negligible magnitude: they each increased the world's total mined gold supply relative to trend by a third.

The gold rushes of the 1850's raised North America and Australia to the ranks of the world's largest gold producers. The expansion of gold production was very rapid. Gold deposits were rich and could be mined by hand. No great input of capital or infrastructure was required before Australia and North America could begin producing gold in large quantities.¹²

The 1880's saw the three largest gold producers—North America, Australia, and Russia, in that order—produce more than three quarters of the total addition to the world's gold supply (Financial Review Annual [1913]). A small discovery of deposits in South Africa led to prospecting which culminated in the discovery of the main reef of gold deposits in the Rand region of South Africa—present day Johannesburg—in 1886 (Wheatcroft [1985]). The 1890's saw significant discoveries in Australia and in North America. By 1906-1910 Australian and North American production had each tripled relative to their 1886-1890 levels. Of the “big three” of gold producers before 1890, only Russia had failed to significantly increase its gold output. But the most dramatic addition to gold output in the post-1890 period came from the exploitation of South African gold deposits, in particular the Rand.

In spite of the discovery of the Rand gold reef in 1886, it took almost a generation for mining operations to become fully established. In 1887 South Africa produced only 28,000 ounces of gold. By 1890 production was up to 480,000 ounces. This was less than ten percent of the world's gold production in 1890, only twelve percent of what the Rand would produce in 1899, and only a twentieth of what the Rand would produce in the years immediately preceding World War I. The long lapse of time between the discovery of the Rand on the one hand and the full establishment of gold mining on the other stems from two causes: the poor quality of the Rand's gold deposits, and the isolated location of the gold field. By contrast, the gold discoveries of the 1850's were quickly exploited.

The Rand gold deposits are the largest and among the poorest in the world. By 1889—only three years after the discovery of the gold field and after only some 600,000 ounces had been recovered—gold production in South Africa faced a technological barrier. The remaining gold was spread thinly throughout quartz and sulfur-iron pyrite; previous standard methods of extraction could not be used. The telluride ores of Australia and Colorado can in the most favorable cases contain up to a quarter gold by weight, but ores in South Africa contained less than one-tenth of one percent gold (Wheatcroft [1985],

Goldmann [1899]).

The only way to recover gold from ores as poor as those of the Rand was the untried and newly invented cyanide process. Finely-ground ore is added to a solution of calcium cyanide and lime. The gold combines with cyanide, and can then be precipitated by adding zinc. The cyanide process can extract up to nineteen-twentieths of the gold in the ore (Wise [1964]).¹³ Profitable use of the cyanide process requires the processing of enormous amounts of ore, and the was a very capital and technology intensive industry by the standards of the 1880's and 1890's.

Gold mining in South Africa was thus a very different industry from the placer, hydraulic, or lode mining of Australia or North America. Gold mining in South Africa involved the large scale use of recently-discovered organic chemical processes: South African gold production was one of the high-tech industries of the 1890's. The sophistication of the technology and the large size of efficient scale quickly led to the consolidation of the South African gold industry into a tight oligopoly under the leadership of Rhodes and Oppenheimer.¹⁴

Given the sophistication of the technology required to exploit the Rand and the gold's location far inland from cheap transportation to Europe, it seems natural that it might take more than a decade for exploitation to reach full intensity. In 1886 there were some 1800 miles of railroad laid in South Africa, but they were concentrated near the Cape of Good Hope to provide a network for the export of agricultural products. The furthest north the railroad line from Cape Town reached in 1886 was the diamond town of Kimberly, on the border of the then-independent Orange Free State, and still some 300 miles from Johannesburg (Hobson [1900], Wheatcroft [1985]).

By 1895 railroad mileage had doubled from 1886. Johannesburg was connected by rail to seaports from Cape Town on the Atlantic to what was then called Lorenzo Marques in what is now Mozambique (Wheatcroft [1985]). The investment required to establish the South African mining industry and link it to industrial Europe was being made. By 1913 the total British capital invested in South Africa amounted to some £27 per capita—about equal to a year's worth of South African gross national product. More Western European capital was invested per capita in South Africa than in any other area of the globe outside the regions of mass European migration and settlement in Argentina, Australasia, and Canada (De Long [1988]).

There is reason to believe that analysts could have foreseen the expansion in production before it was well under way (Wheatcroft [1985]). This point is reinforced by parallels between the gold discoveries at the end and in the middle of the nineteenth century. The gold booms of the 1850's and the

1890's involved very similar sudden shifts in the rate at which the world's total supply of gold was increasing. Anyone who believed that investors and traders have to learn how prices respond to shocks still has to confront the fact that investors and traders could learn about the shifts in the monetary environment likely to come in the 1890's by studying the 1850's before she can conclude that the effects of the South African gold discoveries took the world by surprise.

From the perspective of an investor in the 1890's, uncertainties intervene. Before anyone could conclude that the rush of the 1890's was of a magnitude similar to the rush of the 1850's, she would have had to resolve three questions: First, how fast would the gold of South Africa be mined?¹⁵ Second, how long would the gold last? Third, would there be any offsets from central bank behavior? Would the increase in total gold induce an increase in private gold reserves, an increase in sterile public gold holdings, a substitution of gold cash for fiduciary money, or even an expansion in the gold area itself? Disturbing causes at any one of these points could interrupt the quantity-theoretic transmission mechanism that leads from the gold stock to the price level.

IV. STATISTICAL FORECASTS OF INFLATION

As Barsky [1987] argued, the absence of any correlation between ex post inflation rates and nominal interest rates may not be strong evidence against the Fisher effect. If inflation was unforecastable, there would be no correlation between ex post inflation and interest rates even if the Fisher effect did hold. One way to assess the forecastability of inflation is to estimate univariate stochastic processes for inflation and see how much of inflation variance is predictable from its own past. A lack of serial correlation in inflation might be a sign that investors before WWI found inflation very difficult to forecast. As Barsky [1987] stresses, Box-Jenkins procedures at both quarterly and annual frequencies identify the price level over 1870-1914 as a random walk with little drift, and the inflation rate consequently as approximately zero-mean white noise without any sizeable or shifting persistent component, in both the United States and the United Kingdom

Inflation under the gold standard thus shows little persistence. The pace at which gold was mined as plotted in figures 5 and 6 exhibits great persistence. Yet the two variables—transitory inflation and persistent gold production—do exhibit a noticeable correlation, as figures 7 and 8 show. The simple correlation between this year's inflation and last year's gold production is .4 for the United States and .2 for the United Kingdom using the 1870-1914 sample period, and .3 for either the United States or the

United Kingdom over the 1879-1914 period. A small, but nonzero part of the year-to-year variance in inflation is forecastable from knowledge of one lag of gold production.¹⁶ The correlation between the persistent gold production series and the volatile inflation series comes from the association of the upward leap in gold production in the 1890's with the upward shift in average inflation. But the correlation is not solely the result of this one shift in gold production. Consistent wholesale price indices for Great Britain exist for the entire nineteenth century. They reveal that the correlation between price changes and gold production holds, for the gold standard country of Great Britain, just as strongly for the pre-1870 as for the post-1870 period:

The predictability of inflation from gold production leads one to expect a correlation between nominal interest and that portion of inflation which is itself correlated with gold production. But as table 3 below shows, instrumental variable regressions of interest on ex post inflation rates—which would produce coefficients of unity if past gold production was properly used by the market to forecast future inflation and if the Fisher relationship held—in every case produce coefficients that are near zero. Nominal interest rates do not rise in parallel with the component of inflation forecastable by past gold production. This failure is the principal strike against the Fisher effect.

One objection to table 3 is that even if gold production is useful for forecasting inflation over 1870-1914 ex post, it is not necessarily the case that rational traders and investors could, or should, ex ante have expected gold production to be useful for forecasting inflation. This objection, however, is hard to sustain if one analyzes the 1895-1913 gold boom in the context of the gold boom of the 1850's. As table 4 and figure 9 show, gold has a positive correlation with inflation over every part of the nineteenth century for the United Kingdom, which had remained on the gold standard from the end of the Napoleonic Wars until the beginning of World War I.¹⁷ An investor applying the standard hypothesis-testing methodology to these data would, by 1900, have been able to reject the null of no relationship between gold production and inflation at the .05 level. The association before 1900 could therefore have given investors a reason to pay close attention to gold production in forming forecasts of likely future price changes in the 1890's and after.

V. ACTUAL EXPECTATIONS OF INFLATION BEFORE WORLD WAR I

It might appear that we could conclude the paper here, and confidently state that there is strong evidence that money illusion was the rule rather than the exception before World War I—even among that

critical mass of well-informed speculators that economists argue will tend to drive prices in financial markets toward their fundamental values (Friedman [1953]). But the case for the conclusion that investors ought to have been using gold production to forecast future inflation rates may not be as strong as it appears. Up to this point we have followed the accepted canons of procedure by assuming that investors know the parameters of the model—that lagged gold production belongs in the list of the determinants of inflation, and that the reduced-form relationship between gold production and long-run average inflation is relatively stable. But if investors are uncertain about the underlying model, then it is no longer clear that the instrumental variables regressions of tables 3 and 4 are powerful evidence against the “rationality” of market participants. Only if investors knew a priori both the rate at which changes in gold production translated into changes in long-run inflation rates and the degree to which this reduced form relationship was stable, is it clear that the optimal forecast of inflation would pick up the shift in inflation in the 1890’s as it took place.

In this section we consider not what inflation expectations should have been but what actual inflation expectations were, and with why such expectations were held. We examine two bodies of evidence, first the academic debate over the quantity theory and the causes of secular changes in prices carried out in the forerunners of the American Economic Review, and second the journalistic assessments of gold, prices, inflation, and interest rates contained in the London Economist. Although we find a great deal of interest in the rate of gold production and the causes of secular price changes, we find no consensus of informed positions and no explicit forecasts of positive inflation in the years before WWII.

Academic Opinion

An American bond trader who turned to academic opinion for inflation forecasts for a model on which to base an analysis of price level changes faced no easy task, for economists in the United States were divided. One could not read the literature put out by economists in search of an answer unless one was willing to become an economist, and to judge the monetarist-antimonetarist debate for oneself. Belief in the quantity theory would have allowed investors to recognize the shift in average inflation, but no investor approaching the economic debate uninformed would come away convinced that the quantity theory was the proper framework to use to analyze inflation. On the monetarist side of the debate stood economists like Irving Fisher, who were strong believers in the quantity theory and in the close dependence of the quantity of money on the gold stock. On the other side stood economists like Laurence Laughlin and David Wells, who believed in a “cost of production” theory of the price level.

Laughlin [1894], for example, claimed that “it is arrant demagogism to try to make cotton growers believe that the free coinage of silver can in any way restore the price of cotton, when the fall is due to excessive crops.” Wells [1895] argued that “the recent phenomenal decline in prices [over the preceding twenty years] is due so largely to the great multiplication and cheapening of commodities through new conditions of production and distribution, that the influence of any or all other causes combined in contributing to such a result has been inconsiderable.” Wells attributed the decline in the nominal price of wheat, for example to declines in freight charges, claiming that reductions in transportation costs were “an agency which sufficiently accounts for a great part of the decline in the price of wheat, and which would have operated all the same even if the relative values of the precious metals... had remained unaltered.”¹⁸

Orthodox monetarist critiques of Laughlin and Wells appear, to us, convincing. Kinder [1899], for example, points out that transportation costs had been falling and production growing for decades before 1870 and had not then been accompanied by falling prices. Irving Fisher [1911] convincingly decomposes changes in prices into changes caused by movements in real income, by movements in velocity, and by movements in the money stock. Yet the anti-monetarists are not convinced. Of the five joint discussants of Fisher [1911] and Laughlin [1911] at the 1910 American Economic Association meetings, three criticize Fisher and support Laughlin by arguing that the money supply is endogenous and has at best a tangential relationship to the gold stock: money does not cause prices, prices cause money.¹⁹

The assessment of American economists as evenly split between supporters and opponents of the quantity theory is not ours alone. Keynes [1912], lecturing his students at Cambridge before World War I, declared that in Britain the dominance of the quantity theory was complete, but that in America the profession was fairly evenly split.²⁰

The lesson we draw is that any American trader who, before World War I, turned to the literature of academic economics for help in untangling the determinants of price level changes faced a difficult task. In the United States a respected economist could be found to set forth either the conclusion that changes in the long-run rate of drift of the price level were due to changes in the volume of gold production, or that changes in the long-run rate of drift of the price level were not due to changes in the volume of gold production but to “such things as labor unions, monopolies, extravagance, the tariff, general prosperity, etc.” (Houston [1911]). Even in Britain, where the community of academic economists was effectively united, they perceived themselves as having little influence on the thinking of people of affairs. Keynes

[1912]—then still a strong monetarist— lamented the fact that :

a rise in prices always appears to be due to ‘conditions of trade,’ and in the case of every article taken by itself a rise in its price is always due to an increase in the demand for it or to a decrease in the supply... as a proximate cause. This is the chief reason why some bankers and many businessmen have always been inclined to doubt the connection of the level of prices to the volume of money— because they cannot perceive through what channels the influence of the one upon the other is exerted.

The following year saw the influential and respected—though non-academic—analyst J.A. Hobson [1913] argue that the correlation between gold production and inflation over the preceding half century was a coincidence and not a sign of the quantity theory at work.²¹ The disarray of the economics profession in the United States, and the lack of authority of the economics profession in the United Kingdom, made it unlikely that participants in the financial markets would be taught by economists to use the quantity theory as a basis for analysis and forecasting.

The Economist and Its Forecasts

We have also searched for signs that the commercial and financial world had reached practical conclusions about the structure of the economy that the academic world had not. We have sought for some sign that the presence of lagged gold production in agents’ information sets did lead at least some to anticipate rises in prices as a result of gold discoveries.

Our search took us to the London Economist, as the natural place to find such anticipations if held. The London Economist stands out as a stronghold of the quantity theory throughout the pre-World War I gold standard period. It (August 14, 1897) heaped scorn on Sir Robert Giffin, who had set himself to demonstrate that “it is the range of prices... which helps to determine the quantity of money in use, and not the quantity of money in use which determines prices.” As a stronghold of the quantity theory, this newspaper should be the locus of much writing that gold discoveries will change the long-run rate of drift of the price level. Yet the quantity-theoretic Economist does not forecast that the wave of gold discoveries in the 1890’s will have an appreciable effect on prices.

It is not clear how much weight we should place on our inability to find explicit forecasts of future prices that recognize the shift in inflation that took place around 1896. We have negative evidence only: the dog did not bark in the night. Nevertheless this newspaper—with its commitment to the quantity theory, and its long-standing established intellectual predisposition to analyze and theorize about the

economy rather than merely report—did not make the inflation forecasts we regard as natural. It did not project inflation on past gold production and use this projection to assess likely future price changes. This suggests to us that few if any investors in the pre-World War I period saw the relationships between gold and money and between money and prices as sufficiently strong and reliable to be useful for forecasting purposes.

The Economist did recognize that the world's rate of gold production had undergone a substantial shift even before the trough of the price level in 1896. In 1895, when the newspaper attempts to assess the likely effect of the gold discoveries of the 1890's, it looks back to the Australian and Californian gold rushes of 1848-1851. Some then thought that such a wave of gold discoveries must have had large effects on prices. An 1872 letter to the editor (Thomas Hankey, June 15, 1872) notes that gold production from 1850-1870 was equal to the amount of gold brought to Europe from Latin America over 1500-1800, and asks whether "a great effect [on prices] must not now be experienced by the additional production of an equally large amount during so comparatively a short time as twenty years?"

The Economist's 1872 answer is that it did not, that the rise in gold production in the 1850's had no appreciable influence on the course of the general price level. It stresses how "neutralizing circumstances... the great increase of population and wealth which has occurred... since 1848" raised the demand for gold sufficiently that the increased supply did not lead to any price rises. The conclusion ultimately arrived at is that "we should be inclined to doubt whether it could be proved that the general purchasing power of the sovereign has much diminished since 1850" (June 29, 1872).²²

In 1895 the Economist bases its judgment of the likely effect of increased gold mining on its perception that the burst of mining around 1850 had little effect on the price level:

"When some fifty years ago, first California and then Australia began to pour out... gold, the Gold Question... came... to be the great economic question of the day.... Broadly speaking, the general expectation was that, owing to the enormous increase in output... there would be a great diminution in the purchasing power of gold or... a great rise in the prices of commodities.... It did not take long, however, to prove that... the hopes and fears excited by... new gold... were greatly exaggerated.... Thus Professor Jevons, writing in 1863, pointed out that 'even after the lapse of ten or twelve years, men who give their whole attention to monetary matters... remain in a state of doubt as to whether any depreciation of gold is really taking place'. And as late as 1873, while maintaining that he had been right in predicting a depreciation of gold, Professor Cairnes wrote 'It is now generally agreed that within twenty years a substantial advance in general prices has taken place. But beyond the general conviction there is little accord. People differ as to the extent of the advance and as to its cause.... Amongst economists... it is pretty well agreed that the advance is... due to... gold discoveries. But... there is, on the part of

commercial writers and... all who view the question from the standpoint of practical business, a strong disposition to ignore... the influence of this cause” (September 28, 1895).

The quantity-theoretic link between the quantity of gold and the level of prices is thus seen as weak in general. The Economist is doubtful that gold mining will raise prices in the particular instance of the South African gold discoveries for at least three reasons. The first is its—ex post false—assessment that the extent of the Rand discoveries will never match in total volume of gold those of the Californian and Australian discoveries of mid-century. The second is the Economist's belief that what matters for the price level is the proportional increase in gold and the gold stock is much larger. And the third arises from the fact that conditions of production are different, that South African gold mining is a very capital intensive industry (September 28, 1895) as discussed in section II above. From our perspective, the Economist was wrong ex post. But it is not clear that the Economist was wrong ex ante. And it certainly is not the case that the Economist's position can be classified as “irrational” in any strong sense.

Two further years of gold production do not change the newspaper's unwillingness to see the Rand gold discoveries as a source of inflation. On January 16, 1897 the newspaper congratulates itself on having avoided speculating about the likely effects of increased gold production: “When the first important spurt in the new supplies of gold took place... there was a good deal of talk about the possible effect of the increased production upon the prices both of commodities and of securities; but no such result has yet made itself apparent.... [T]he fact is that this large increase in the output of gold has produced very little appreciable effect... for the... reason that... an increased production of three or four millions a year is, relatively speaking, a small matter.” And by July the Economist suspects that the entire Rand gold field is close to the edge and is only marginally profitable: “Of the 46 Witwatersrand mines which were crushing during the first quarter... the yield of no less than eighteen was under 30s a ton, and only ten mines yielded over 40s a ton. Until very recently the average total cost on the Rand for working a ton of ore was quite 30s” (July 10, 1897). The only hope they see for a continuation, let alone expansion, of the pace of mining on the Rand is if the employers' cartel is successful at reducing the wages of Black miners.

The Economist's distrust of the permanence of the higher level of gold production is still apparent as late as 1904, when its South African correspondent writes: “The world's output of gold this year will be... not less than £70,000,000 and is likely to be the greatest on record.... But the discovery of new mines is not keeping pace with the exhaustion of those now being worked, and it seems to me that in a few years the output must reach its zenith and then gradually decline” (September 17, 1904). If the shift in

production was not seen as permanent, then there is less reason for expecting it to affect the price level.

Some South African mines did close unexpectedly. Wheatcroft [1985] notes in particular the large losses incurred by speculators in the shares of South African mines in the late 1880's as allegedly promising mines closed. South African mines continued to be perceived on the London capital market as highly speculative investments throughout the pre-WWI period, perhaps reflecting uncertainty about the likelihood of widespread mine closings.²³

Only in 1908 do we find forecasts of inflation. The first comes in a letter to the editor. C.H. Bennett predicts that “there will be a rise in about ten years of between 5 and 15 percent in general prices... if no other great influence interferes.... The great stimulation of industry, causing a high rate of interest, will naturally lower the price of fixed interest-bearing securities in the long run” (April 11, 1908). He sees not only a link between gold mining and prices but also a link between inflation and the rate of interest. But he speaks of the Fisher effect—the lowering of the price of fixed interest-bearing securities—as something that has not yet occurred but that will come to pass “in the long run.” And on December 5, 1908 comes the Economist's attribution of the rise in prices since 1896 to the increase in the gold stock. In response to the question “Has Gold Depreciated?” the newspaper answers in the affirmative: “The quantitative theory of money, with such modifications as have become necessary with the wider use of credit, undoubtedly holds the ground.” But even here the newspaper eschews forecasts of future inflation.

The Economist notes that modern economies can successfully economize or not on expensive gold: “The spread of banking.. and the development of the use of cheques, have checked a demand for gold which might otherwise have sprung up.... The effect of this economy is very difficult to measure, but its direct tendency is unmistakable, and must have been very powerful.” Stress is placed on the increased demand for gold arising from an enlargement of the area covered by the gold standard. “If other commodities are unchanged, and population and business are the same, then if a sovereign is reduced to the value of half-a-sovereign, double the number of sovereigns will be required to make the same payments,” but “the qualification that other things must be the same is very important...” (December 28, 1872).

To place the concerns of the Economist's editors in an analytical framework, consider the forward-looking version of the simple monetary model of Cagan [1956]. Let (log) money demand be given by:

$$(1) \quad m_t - p_t = - (E_t p_{t+1} - p_t)$$

where m and p are the logs of the money stock and the price level, respectively. The log of the money stock is the sum of the log of the gold stock and the log money multiplier:

$$(2) \quad m_t = \mu_t + g_t$$

We assume that the (log) money multiplier bears a systematic negative relation to the gold stock: both central banks and private institutions economize on gold when it is scarce.

$$(3) \quad \mu_t = - \alpha g_t$$

Last, we assume that the proportional rate of increase in the gold stock $g_t = g_t - g_{t-1}$ is very persistent from year-to-year with a high probability β , but that with a small probability $1-\beta$ in any given year any current bulge in mining may disappear, and production may drop down to its long-run trend level. In either case, there is also a white-noise disturbance ϵ_t to production:

$$(4) \quad g_t = \begin{cases} \beta g_{t-1} + \epsilon_t & \text{with probability } \beta \\ \epsilon_t & \text{with probability } 1-\beta \end{cases}$$

In this model the expected inflation rate is given by:

$$(5) \quad E_t\{p_{t+1}\} = \frac{(1-\beta)}{1 + \beta(1-\beta)} g_t$$

Expected inflation rises less than one-for-one with the rate of increase in the gold stock. The proportionality coefficient depends on three parameters: the money demand elasticity α , the probability that gold mining will persist at or near its current level, and the value β of the endogenous offset of new gold by changes in the gold ratio within the world's banking system. If a current high rate of gold mining

is thought likely to persist indefinitely (ρ close to one) and if endogenous offset is small (α near zero), then inflation will move almost one-for-one with gold production. However, if the exhaustion of mines is seen as a serious possibility ($\rho < 1$) or if the endogenous offset α is thought to be large, then a rational Economist should not have believed that the expansion of gold production in the 1890's signaled a commensurate rise in the future inflation rate.²⁴

Moreover, from the perspective of an analyst in the 1890's, the past relationship between gold and prices carries little information about what either the offset parameter α will be in the changed monetary environment of the end of the nineteenth century, or what the persistence ρ of gold mining is likely to be in the new and technologically untried mines of South Africa. The existence of a peso problem—a possible but unlikely extreme event not observed in the sample—creates problems not only for the economist but also for the investor. A peso problem prevents an economist from identifying the parameters of the model. Perhaps more important, it may also prevent an investor from determining the laws of motion of the economy.

If any set of investors and writers were using lagged gold production to forecast future inflation, one would expect to find traces in the Economist. It was a newspaper that had always cherished close connections with the dismal science. It had no institutional or political bias against the quantity theory—its very refusals to forecast inflation are in general justified by the language of the quantity theory. And it paid great attention to the rate at which gold was being mined throughout the world. Yet the newspaper always, up until 1908, assesses the situation in such a way as to reject the conclusion that the gold discoveries of the 1890's will be followed by price inflation. And it has good reasons, or at least defensible rationalizations, for its judgments: the money multiplier is changing, the velocity of money is changing, the rate of growth of real output in the world is changing as industrialization spreads, the increase in gold mining will have no appreciable influence on the rate of growth of the gold stock, or the Rand deposits cannot be mined for long without becoming exhausted. Though the newspaper's forecasts are wrong ex post and use of them would lead to rejection of the joint null of rational expectations and the Fisher effect at standard significance levels, we cannot bring ourselves to say that the Economist was not processing available information in a reasonable fashion. Ex post, their judgments about the structure of the economy and the lessons to be learned from the 1850's were wrong. But when considered from an ex ante standpoint, their forecasts and arguments appear to be a serious and theoretically-informed attempt to assess the likely future course of the price level.

VI. CONCLUSION

Many tests reject rational expectations because orthogonality conditions are not satisfied (Rotemberg [1984]). These conditions have the natural interpretation that forecast errors should be uncorrelated with variables known to be in agents information sets: in this context, the expectations of inflation implicit in interest rates do not depend on gold production in the same way that actual inflation depends on production.

Such a finding is indicative of suboptimal forecasting if investors know the structure of the economy and can be presumed to have access to the relevant economic theory ex ante. But we do not necessarily see the actual discussion of the relationship between gold discoveries and the price level contained in the Economist as showing a failure to rationally process available information. The Economist's model of the economy did turn out to be incorrect ex post. But this does not mean that the Economist was irrational in believing that increases in gold production were not likely to be of enough magnitude to change the long-term drift of the price level. The Economist's failure to predict inflation cannot be easily traced either to an obvious flaw in logic or to an obvious failure to process readily available information in a careful and utility maximizing manner.

We have argued that the failure of agents to exhibit “foresight” with regard to the change in the trend inflation rate after 1896, while inconsistent with some tests of “rational expectations,” is not persuasive evidence that investors were negligent or naive in processing information. Previous experience with gold discoveries did not necessarily provide an adequate basis on which to judge either the extent to which the flow of new gold would continue at its rapid rate, or the extent to which the institutions governing the velocity of gold might adjust endogenously to the change in the rate of mining. The (weak) correlation between gold production and price changes in the 1850's would not necessarily lead one to expect this correlation to hold in the different mining and monetary environment of the 1890's. From this point of view, the absence of a pre-1914 Fisher effect is not completely surprising.

From the perspective of the mid-1890's, how would an investor rationally decide what structural parameters would be appropriate for understanding the future relationship between gold and inflation? These issues are easily overlooked by the econometrician, who can with hindsight estimate the “true model” and may ignore the range of parameter values that may have appeared possible to investors at the time. Economists today reach little agreement on the structure of the economy. Different economists today thus presumably believe that expectational errors are orthogonal to different information sets—and

that investors who form forecasts according to the theories held by their colleagues are “irrational.” It seems overly harsh to conclude that a failure of expectations implicit in prices to match up with a particular favorite model is evidence of money illusion or of a failure by investors to adequately use the information at their disposal.

APPENDIX: FREE SILVER

We have already discussed the potential peso problem in the pre-World War I era associated with the possible, but not observed, collapse of the South African gold rush. There is one other event that might have but did not occur and that would have had a serious effect on prices: a political victory for free silver forces in the United States and a consequent devaluation. The failure of a Fisher effect is stronger in United States than in United Kingdom data. If the marginal investor in dollar-denominated bonds priced her consumption in sterling, it may be that for the United States the magnitude of the apparent failure of the Fisher effect is doubled by the coincidence of the shift in inflation and the defeat of the free silver movement. Before 1897 it was not certain that the United States would remain on gold. An investor in London seeking an equivalent sterling rate of return would have demanded a premium face interest rate on dollar-denominated assets to compensate for the perceived possibility of United States abandonment of the gold standard and free coinage of silver. Although the United States did stay on gold, it would have been irrational ex ante to assume that it would remain on gold with certainty (Goodwyn [1978]). After 1897, populism disappeared as a political force and free silver disappeared from the political agenda. The expected depreciation premium that United States nominal interest rates arguably commanded over British rates before 1897 was most likely gone by the decade and a half before World War I.

Thus United States interest rates during the first half of our 1870-1913 sample may suffer from a peso problem. Ex ante sterling-denominated United States interest rates were persistently lower than ex post sterling denominated interest rates. Calomiris and Hubbard [1987] document the association between changes in United States and United Kingdom short interest rates after 1898. Using quarterly data, the correlation between changes in commercial paper rates is .61 and the slope of a regression of changes in United States on United Kingdom rates is .86 with a standard error of .14. Using annual average data, the correlation between changes in year-to-year averages is .89, and the regression slope is .87 with a standard error of .12.

As figure 11 shows, such tight relationships do not hold for the pre-1896 period when populism was strong. Using annual average data, the correlation between changes in short-term commercial paper rates is .53 and the correlation between long-term bond rates is .04. A considerable part of the shifts in yields calculated for United States long-term bonds is due to changing perceived probabilities of bankruptcy for

United States corporations. However, the failure of anything like interest parity to hold for New York and London commercial paper rates before 1896 suggests that perceived exchange risk was breaking the link between short-term rates that one would expect to see under the gold standard.

The difficulty with attributing shifts in the London-New York nominal interest rate differential to a free silver peso problem is that such an explanation implies an implausibly high probability of success for the free silver movement. While the United States was on the international gold standard—1879 to 1913—nominal commercial paper interest rates averaged 2.6% higher in the United States over 1879-1896 and 1.6% higher over 1897-1913. If we attribute the post-1896 drop in the average interest differential to the removal of a free silver peso problem, then the expected depreciation of the dollar over the 1879-1896 interval was 18%,²⁵ which is large compared to the approximately 25% discount at which the silver in a silver dollar sold on the open market relative to the gold in a gold dollar.

If the difference in pre- and post-1896 interest rate differentials reveals expected depreciation, then we can calculate the cumulative probability that the United States would remain on the gold standard over the entire 1879-1896 period. We then conclude that we live in an unlikely world. Let p_t be the probability that the “free silver” forces would win in year t , forcing the United States off the gold standard, and let d_t be the expected depreciation of the dollar in year t . If the free-silver forces had won, they could not have driven the value of United States currency down by more than 25%. The cumulative likelihood, therefore, that the United States would stay on the gold standard at some point the free-silver forces would win an election and abandon the gold standard is one minus the probability that free silver forces would never win in any year, or at least 0.52.²⁶

This fits uneasily with the assessments of American historians. American history is generally written as though the populist, free-silver Democrats had little chance of putting their policies into effect. They were a regional, pro-inflation interest that developed little support outside their midwestern heartland (Goodwyn [1978]; Hofstadter [1948]). The fact that backing out depreciation expectations from London-based interest differentials gives such a different assessment of the probabilities of populist success from the interpretations of historians gives us pause. It might well be the case that historians, writing with hindsight, have given the dominance of sound money policies an air of inevitability which they did not possess at the time, or it might be that other factors are influencing the New York-London interest differential.

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¹This argument—that the Fisher effect is theoretically compelling as a long-run, but not a short-run phenomenon—is developed in Friedman [1969] and more fully in Summers [1983].

²If we interpret the differences in price trends after the United States returns to the gold standard in 1879 as reflecting shifts in the real exchange rate, the 1879-1914 period sees first a 15 percent real United States depreciation relative to the United Kingdom up to 1896, and then a 20 percent real appreciation to 1914. If capital was free to flow before World War I and so equalized risk-adjusted interest rates in the two currencies, such large real relative price changes make it impossible for us to expect that both countries will exhibit the full Fisher effect. But the puzzle is that neither country, nor some world average, exhibits the Fisher effect.

³Short-term rates are rates paid on the commercial paper of high-grade companies for the U.S. The British rates are short-term commercial paper rates.

⁴The British rate is the default-free consol rate. The United States interest rate is made up of railroad bonds and contains a substantial and variable default premium. It is likely that that the default premium on United States railroad bonds was large in the 1870's and declined sharply in the last quarter of the nineteenth century as unsound railroads went bankrupt and were reorganized.

⁵See the appendix.

⁶Edelstein [1982] reports that sixteen out of seventeen British industry groups show a lower return to equity over 1897-1909 than over 1887-1896.

⁷Given that one of the principal political issues in the United States of the pre-World War I period was the “free silver” movement, it would be surprising if the risk of future price level changes were not a prominent part of the perceived economic environment. See Goodwyn [1978] and Friedman and Schwartz [1963].

⁸And in fact nearly zero. The average rate of inflation over 1879-1914 as measured by the implicit national product deflator in both the US and UK is close to 0.4 percent per year.

⁹Barsky noted that inflation was slightly forecastable by lagged gold production, but stopped short of examining fully the implications of this observation. Moreover, the restriction of analysis to parsimonious univariate models removed from consideration models with long lag structures that might have picked up a small but important forecastable component in inflation. De Long [1987] pursued that line of approach. Here we pursue the link between gold production and inflation

¹⁰Such myopia could have had major consequences for long-term borrowers and lenders. If shifts in average inflation were truly permanent, then a 2 1/2 percent consol that sold for 100 in the early 1890's would have yielded the same real return only if it sold for 62.5 after 1900. The same real losses would have been incurred over time, instead of all at once, by an investor rolling over short term bonds.

¹¹Barro [1979], along with the other theoretical papers reprinted in the first half of Eichengreen [1985], provides a good summary of the economic theory of the gold standard.

¹²Eichengreen and McLean [1990] analyze the history of gold mining in Australia and California in the nineteenth century, and strongly argue that gold production was more or less independent of the real price of gold.

¹³One major source of increased production in Australia and North America after 1890 was the use of the cyanide extraction process on the tailings left behind by earlier gold mining operations

¹⁴The rapid concentration of the South African gold industry is strongly suggestive of the presence of economies of scale of the sort that Chandler (1978) argues lie behind the formation of large, hierarchically-managed, oligopolistic business organizations in the United States in the late nineteenth century.

¹⁵And would the South African economy hold together? The struggle over the division of production between wages and profits was severe, and much government intervention was resorted to to make sure that wages stayed low enough to give mine owners large profits. See van Helten [1982] and van Onselen [1982], whom Wheatcroft [1985] felicitously describes as “giving Marxist social history a good name.”

¹⁶The only troubling note is the size of the estimated coefficient of the response of the price level to an increase in gold production. The quantity theory would lead one to expect a coefficient of one, yet for the United States NP deflator and the British WP index, the coefficient is closer to two—albeit imprecisely estimated. We discuss the non-structural nature of these regressions in the next section.

¹⁷A similar exercise cannot be carried out for the United States, which inflated and resorted to an unbacked paper currency to fight the Civil War.

¹⁸It is possible to give a quantity theory based interpretation of this statement of Wells': since $P = MV/Q$, a rapid expansion in Q —an industrial revolution—will reduce P . If the growth of MV is relatively stable, fluctuations in P might then principally reflect fluctuations in economic growth. But this interpretation of Wells does not imply that shifts in M and V would not lead to significant shifts in prices, and Wells appears to wish to argue that attempts to raise M will not affect P .

¹⁹Fisher's preeminence in this company, although obvious to us, was apparently not clear to contemporary observers,

especially those outside academic economics.

²⁰Keynes attributed this fact to the failure of American economists to read Alfred Marshall. Keynes himself had no doubt but that the expanded pace of world gold production meant, given the long-run trends in real production and in financial sophistication, slow inflation. He predicted that "...it seems likely that the annual rise of prices during the next few years can hardly be less than two or three percent. Credit booms and depressions are likely... to make the upward movement irregular."

²¹There were authors who, by the end of the pre-World War I period, did expect continued inflation. In the United Kingdom see, for example, Barbour [1913], Lehfeldt [1919], and Macindoe [1906]. In the United States see, for example, Brace [1910] and Gibson [1908].

²²According to the available price indices, this assessment by the Economist is wrong. Table 4 above and figure 10 suggest that the gold rushes of the 1850's did have an effect on prices. The break in the 1850's in the declining trend in prices that characterizes the rest of the century should have kept the Economist from concluding that there had been no rise in prices as a result of the gold discoveries of the 1850's. Some contemporary observers did believe that the gold rushes of the mid-nineteenth century had significantly affected the level of prices. See Hoare [1886], Goschen [1883], Jevons [1863], or Stirling [1853].

²³These investments turned out ex post to have been disappointing. Frankel (1967) calculated that the realized return to all South African gold mining equity over 1887-1913 was 2.1% per year, which is to be contrasted with a realized return on South African banking equity of 10.5% per year over 1870-1913. See also Edelstein (1982).

²⁴Consider what would happen in such a model in a period in which gold production does in fact collapse. In such a period, actual inflation exhibits a large negative deviation from trend with a consequent large real capital gain to the holders of nominal assets. This small probability of a collapse in gold production is sufficient to keep the inflation premium in nominal interest rates below the rate of inflation that prevails while the gold rush continues. Since we do not see the end of the gold rush in the pre-1914 period, we cannot easily assess whether the London Economist was wrong in implicitly giving such an end-of-the-gold-rush deflation a relatively high probability.

²⁵This holds if the depreciation risk associated with dollar-denominated assets could be diversified. If this risk could not be diversified, the peso premium would be larger than expected depreciation. We think that risk could be diversified either through the holding of dollar-denominated bonds by those committed to import United States commodities or simply because dollar assets were a small part of Britain's total overseas investment portfolio.

²⁶The probability of free silver victory π_t in the coming year (conditional on there having been no free-silver victory to date) is thus at least four times expected depreciation δ_t . Let π_t be the cumulative probability that the United States would still be on the gold standard in period t . Then:

$$\pi_{t+1} = \pi_t (1 - \delta_t)$$

The cumulative probability that the United States would still be on the gold standard in 1896 having adopted the gold standard in 1879 is:

$$\pi_{1896} = \prod_{t=1879}^{1896} (1 - \delta_t) \exp \left\{ \sum_{t=1879}^{1896} -\delta_t \right\} \exp \left\{ \sum_{t=1879}^{1896} -4\delta_t \right\} \quad .48$$

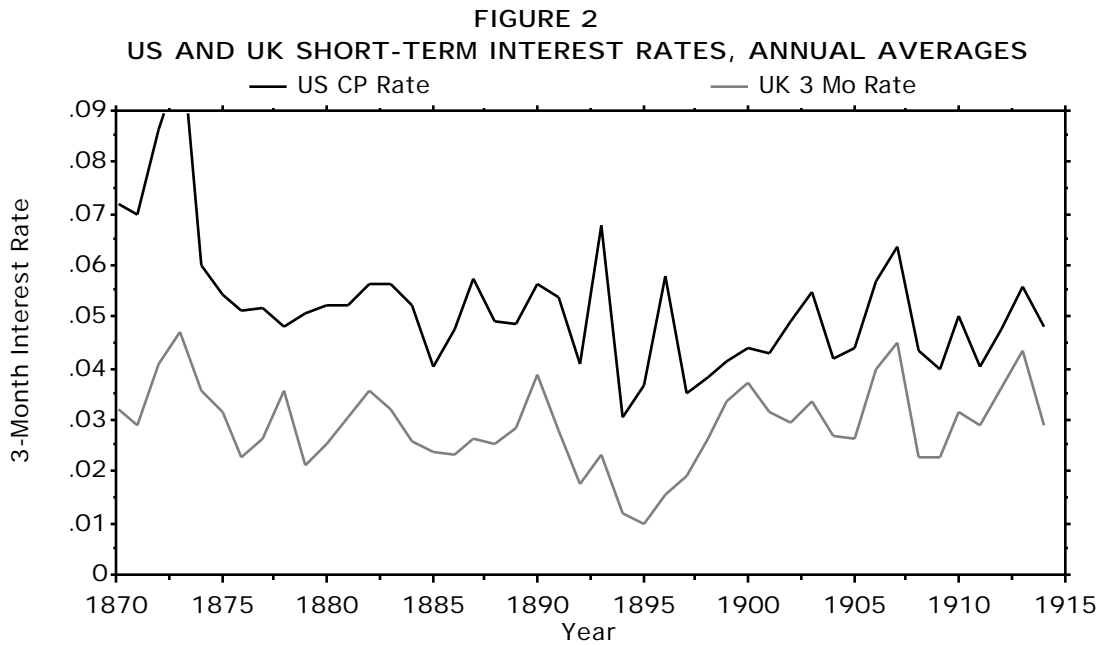
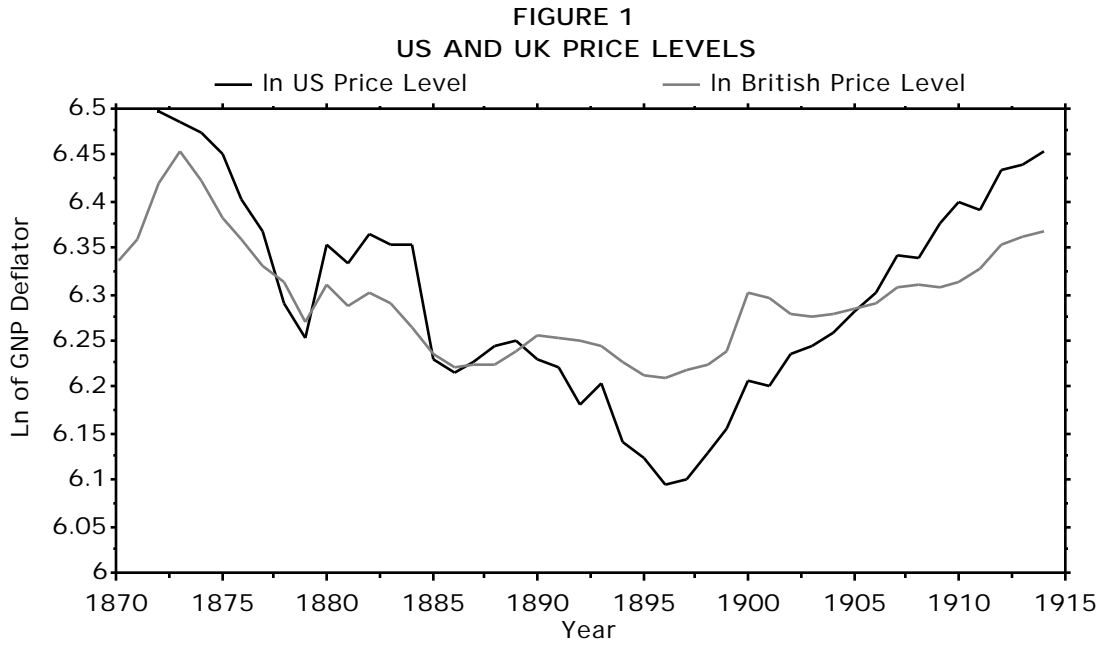


FIGURE 3

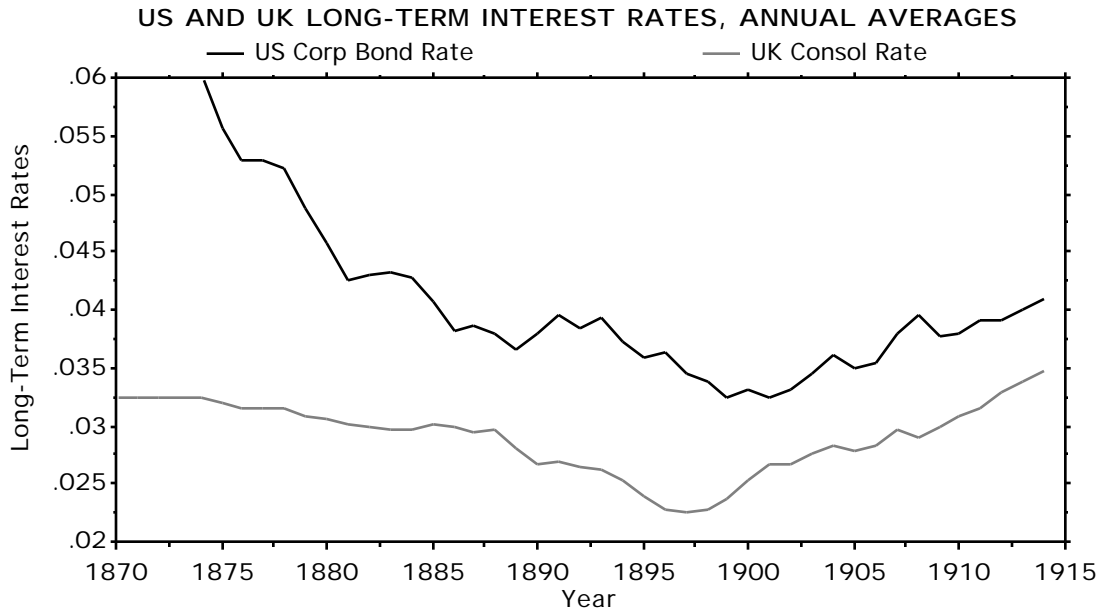


FIGURE 4
COWLES DIVIDEND YIELD ON US EQUITIES

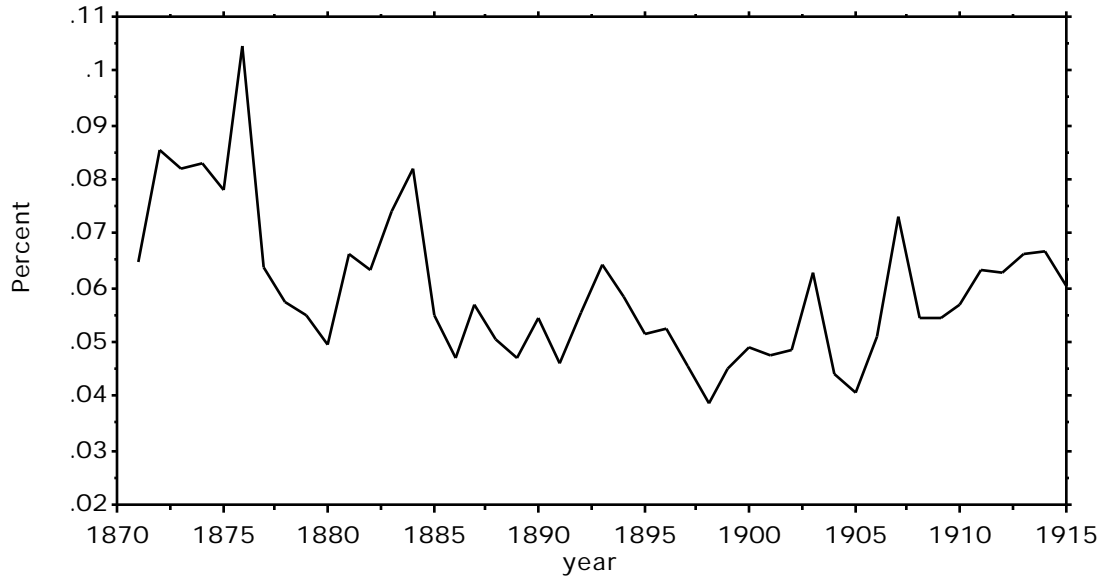


FIGURE 5
ANNUAL LEVEL OF GOLD PRODUCTION

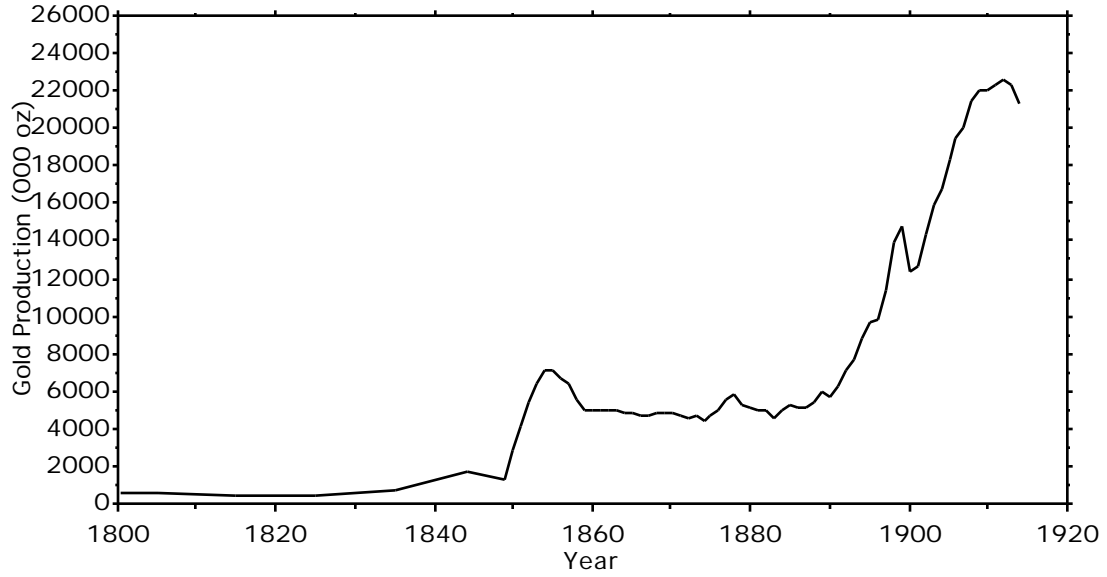


FIGURE 6
RATE OF INCREASE OF CUMULATIVE MINED GOLD STOCK

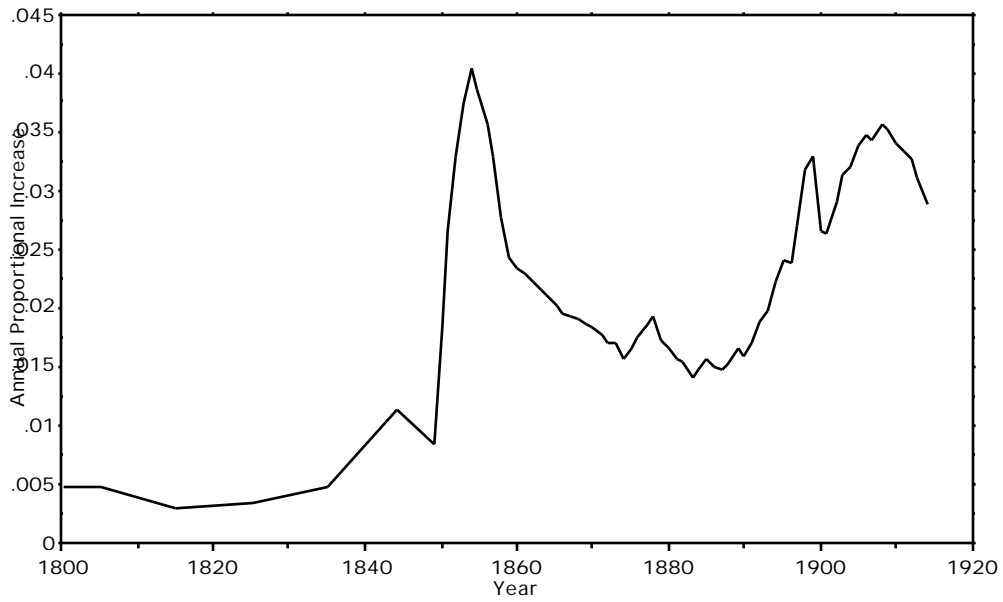


FIGURE 7
US INFLATION AND WORLD GOLD PRODUCTION

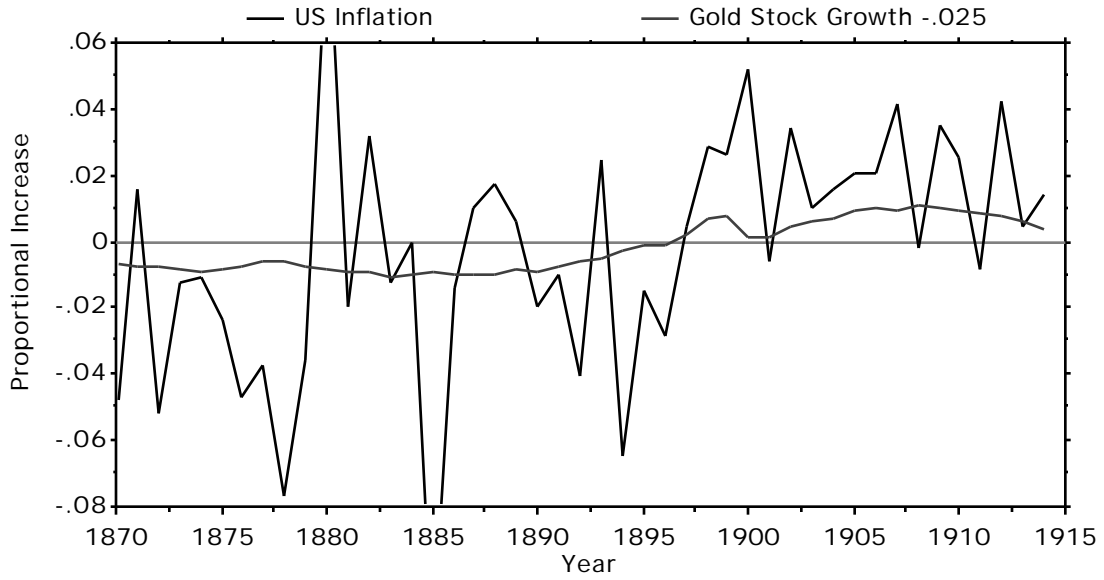


FIGURE 8
BRITISH INFLATION AND WORLD GOLD PRODUCTION

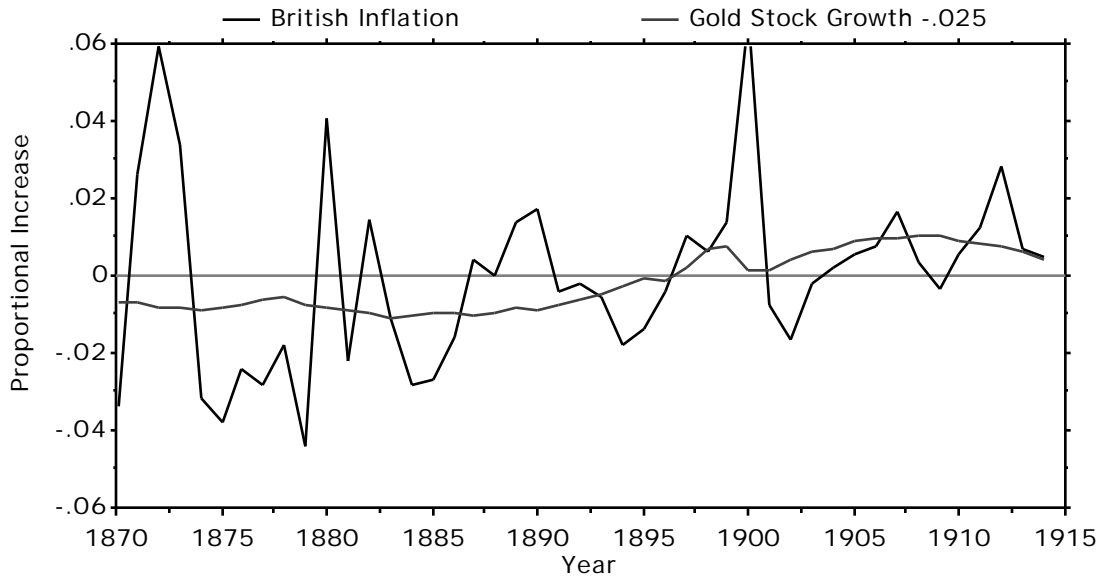


FIGURE 9
STABILITY OF THE RELATIONSHIP BETWEEN GOLD AND THE STATIST WPI

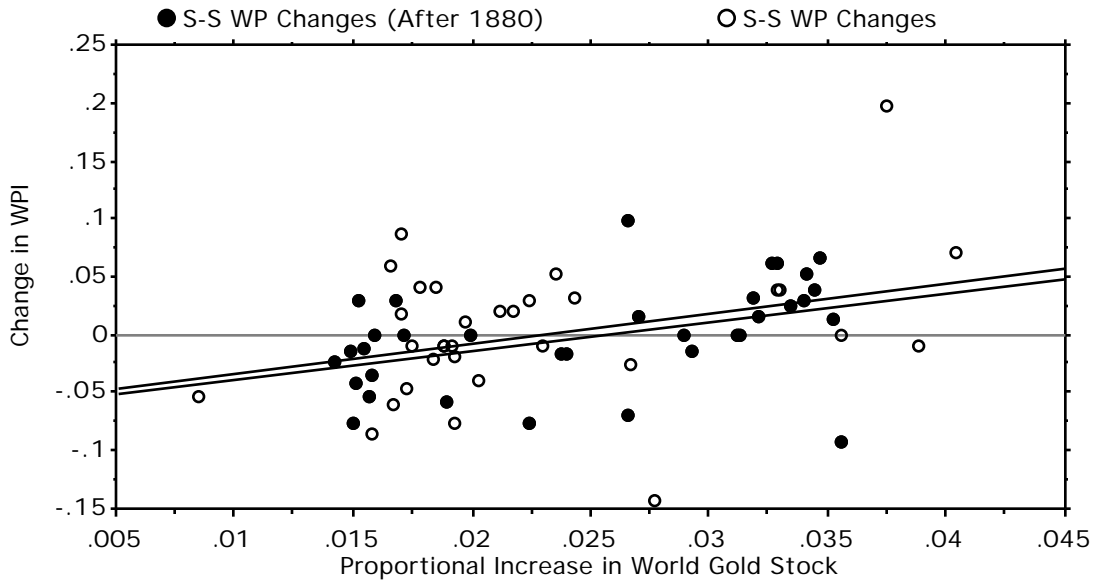
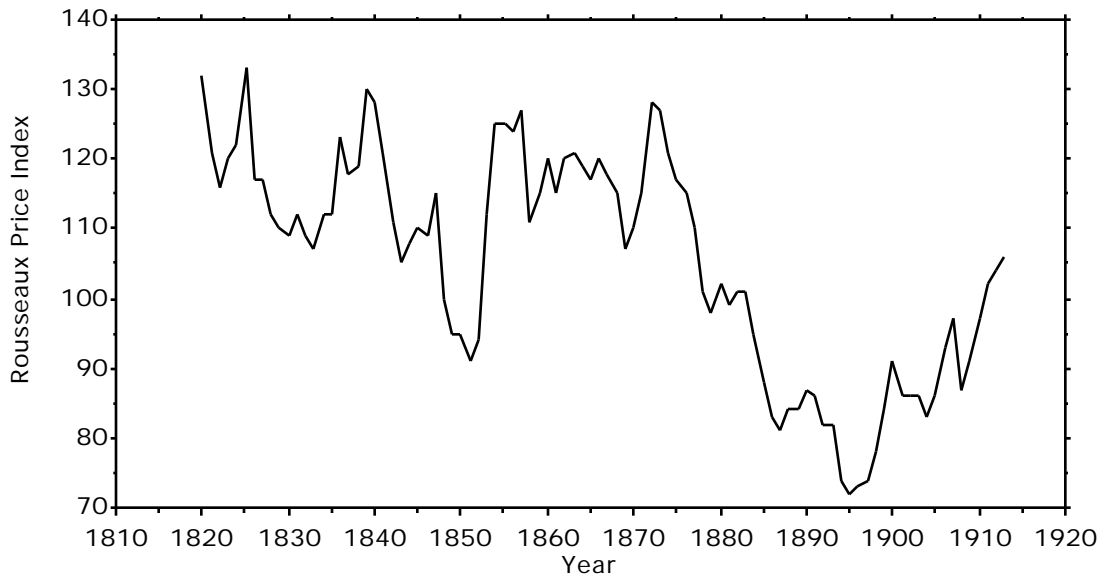


FIGURE 10
BRITISH WHOLESALE PRICES



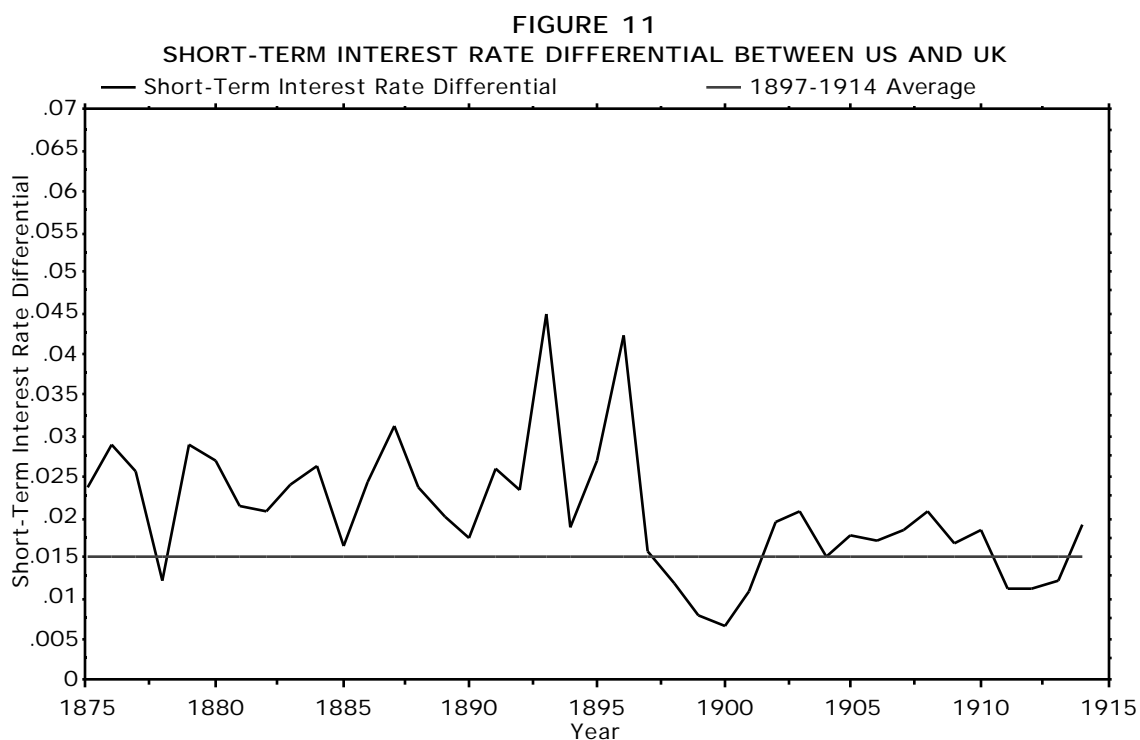


TABLE 1
AVERAGE INTEREST AND INFLATION RATES

Period	United Kingdom			United States		
	3-Month Rates	Consol Rates	Inflation Rate	3-Month Rate	RR Bond Rate	Inflation Rate
1870-1896	2.8%	3.0%	-0.6%	5.7%	4.7%	-1.8%
1897-1913	3.1%	2.8%	0.9%	4.6%	3.6%	2.0%
Change	+0.3%	-0.2%	+1.5%	-1.1%	-1.1%	+3.8%

TABLE 2
INFLATION REGRESSED ON GOLD PRODUCTION

Dependent Variable	Period	Coefficient	Standard Error	Durbin Watson	R ²
US GNP	1870-1913	2.11	0.70	2.20	.16
Deflator	1880-1913	1.65	0.76	2.38	.10
UK GNP	1870-1913	0.79	0.46	1.66	.05
Deflator	1880-1913	0.75	0.41	2.17	.08
UK WPI	1848-1913	2.59	0.78	1.72	.12
(Sauerbeck- Statist)	1870-1913	2.17	0.98	1.64	.09
	1880-1913	2.47	0.91	1.81	.11

TABLE 3
INSTRUMENTAL VARIABLES REGRESSIONS OF INTEREST RATES ON INFLATION RATES, 1880-1914

Nation	Maturity	Frequency	Coefficient	Standard Error
U.S.	Short-term	Quarterly	.054	.213
U.S.	Short-term	Annual	-.239	.140
U.S.	Long-term	Annual	-.269	.100
U.K.	Short-term	Annual	.086	.073
U.K.	Long-term	Annual	.004	.028

TABLE 4
REGRESSIONS OF UK INFLATION ON INCREASE IN WORLD GOLD STOCK USING THE ALTERNATIVE STATIST WPI

Period	Coefficient	Standard Error
1848-1913	2.59	.78
1848-1900	3.29	.98
1848-1890	3.06	1.10
1848-1880	2.97	1.34
1848-1870	3.20	1.53
1870-1913	2.17	.91
1880-1913	2.47	.91